

COPPER EXTRACTION FROM THE DISCARDED PRINTED CIRCUIT BOARD BY LEACHING

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ABSTRACT

Electronics waste (E-waste) is the fastest growing waste stream in the industrialized and urbanized world. Apart from domestic generation in India, the imported e-waste volume is also growing substantially. E-waste is being exported from western countries to Asian countries like China, India, etc. for disposal. Due to lack of proper technology for the recycling of waste electronic equipments, the amount of generation of E-waste is increasing rapidly.

In this paper mechanically pre-treated PCBs are leached with nitric acid and metal Cu distributions in every fraction were determined by using volumetric analysis and it is found that the Percentage availability of Cu in the sample PCB taken is 19.4 Wt%. This Project also deals with the experimental results of the leaching of metal Cu from Printed Circuit Boards (PCB) from obsolete electronic devices by using different combinations of acidic mixture. The crushed PCB was leached by using the aqueous solutions like 2.18N H₂SO₄, 3N HCl, 1N HNO₃ and combination of those acidic solutions at different proportions. The use of low concentration acidic solution is to control the experimental cost and to prevent the environment.

After the leaching of metals, the metal dissolved solution is taken for electro deposition process for the recovery of Cu.

KEYWORDS: E-Waste, Copper, Leaching, Electro Deposition

INTRODUCTION

Millions of Electronic devices have been installed over the past two decades. As new electronic devices come onto the market, significant numbers of old electronic devices are being scrapped. The number of obsolete electronic devices has also been growing. Companies working with the obsolete electronic devices, such equipment are commonly scrapped in inappropriate disposal areas, together with domestic garbage, with no specialized recycling processes.

COMPOSITION OF PCB

Printed circuit boards used in electronic devices are composed of different materials, such as polymers, ceramics, and metals, which render the process of scrappers even more difficult. The presence of metals encourages recycling studies from an economic point of view. However, the presence of heavy metals turns this scrap into dangerous residues. The residues should be disposing of it in a proper manner without harming the environment.

RECYCLING OF PCB

The recycling of printed circuit boards from obsolete electronic devices is, at present, a fairly new activity.

For instance, gold, silver, tin, and copper, among other metals, can be recovered by means of the hydrometallurgical treatment of printed circuit boards.

The Recycling process can be done by two methods

- Thermal Processing
- Non-Thermal Processing

METHODOLOGY

In this Project we have handled the non-thermal processing technique. The Printed Circuit Board was crushed in a ball mill and sieved to separate according to size. The undersized particle was separated which is feed to the Leaching mixture. The powdered PCB was dissolved in a leaching mixture of acids in different combination. Copper present in the PCB are allowed to dissolve in the acidic solutions. The amount of metals dissolved in the solution is determined by using the volumetric analysis method. The use of high concentrations of acids was allowed to control the experimental costs. About 20gms of PCB powder was allowed to react with the 200ml of the leach solution of different concentration. The experiments were carried out at $60\pm 2^\circ\text{C}$. Samples of the leach liquor were collected at intervals of 10, 20, 40, 60, 80, 100 120, 140 and 150 minutes during the experiment.

Leach liquor samples were collected, filtered and sent for chemical analysis to determine copper concentration in aqueous solution.

RESULTS AND DISCUSSIONS

Characteristics and Distribution of Metal in Sample

The PCB samples are collected from the scrap yard and electrical components are dismantled manually. The collected printed circuit boards are fed into the ball mill in order to reduce their size less than 2mm. The PCB's are crushed and sieved in according to their size of different fractions. From the sieve analysis we have calculated the new surface area of the crushed circuit board. The new surface area of the board was found to be $1.6980\text{m}^2/\text{Kg}$. Also a known amount of crushed sample was fed into water and the density of the sample was found as 980.39 Kg/m^3 . Volumetric analysis was performed for treatment of samples dissolved in 50 vol. % HNO_3 . Results showed that copper content in granulated PCBs was 19.46 wt%. Also, distribution of copper in fractions was determined by volumetric analysis.

Table 1: Distribution of Metal in Fractions of Crushed PCB

Size (mm)	Cu Wt%
4.75	21.96
2.80	19.2
1.70	13.4
1.40	15.8
1.00	22.7
0.710	26.3
0.60	24.2
0.425	20.2
-0.425	11.4

Effect of Concentration

The crushed printed circuit boards are allowed to react with the acidic solutions like HNO_3 , HCl , and H_2SO_4 . The concentrations of the acidic solutions are varied from 0.5 to 3.5N. It was found that the metal present in the sample get dissolved into solution with appropriate amount at different concentration of acids. The Metal extracted was plotted in graphical representation and it is found that the optimum concentration for dissolving metal in solutions are 1N, 3N, 2.18N of HNO_3 , HCl , and H_2SO_4 respectively.

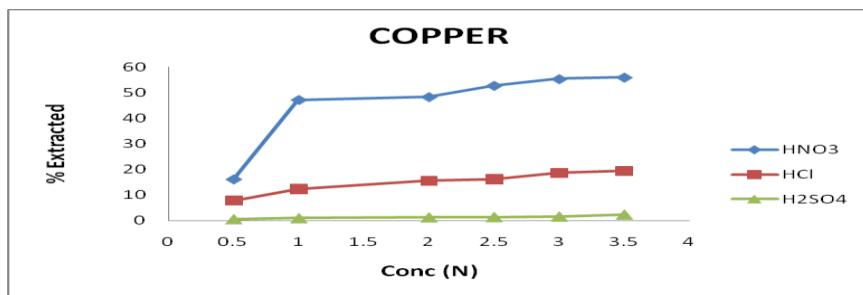


Figure 1

Effect of Temperature

The solvent extraction method was done in order to study the effect of temperature from room temperature (28^0C) to 90^0C . Between the temperature 28 and 60^0C , the extraction of metal varies gradually and difference between at this point is nearest to 40-44%. But after attaining the 60^0C , the extraction goes linearly. Between the temperature 60^0C and 90^0C the change in percentage extraction was found to be 1 to 4.5%.

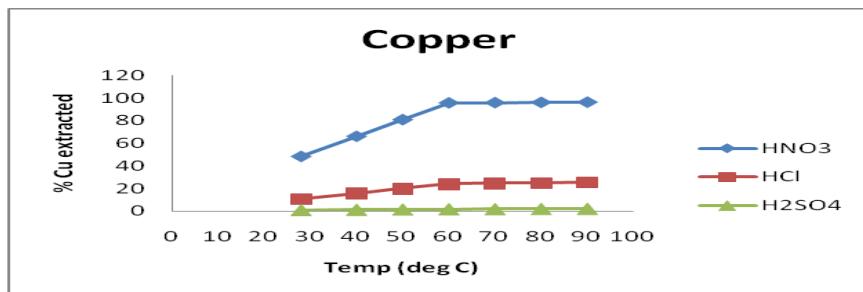


Figure 2

Effect of Reaction Time

From the above studies we have chosen 1N HNO_3 , 3N HCl , and 2.18N H_2SO_4 as solvents for extracting metal at temperature of 60^0C in order to determine the optimum reaction time. The experiments are carried out using these solvents individually and its mixture at different proportions. It is found that the 1N HNO_3 has extracted more metals when comparing to other solvents. It has extracted 95.65% of Copper at temperature of $60 \pm 3^0\text{C}$ ($\text{pH} = 0.89$). The other Solvents like 3N HCl and 2.18N H_2SO_4 does not extracted much satisfactory amount of Copper. The mixture with maximum ratio of HNO_3 has extracted more metals when comparing to other combinations. In the mixture of acid, the maximum value was found in the 1N HNO_3 + 3N HCl (1:1) system. It has extracted 92.7 % of Copper. Weight loss of solids was up to 40% with HNO_3 and was substantially lower with the other two acids. Most of the metals in PCB have reacted efficiently with HNO_3 mainly in hot conditions, achieving recovery yields of 80-95% for Cu.

The use of chloride media seems more adequate for metals such as tin. Tin behaviour is quite complex, since was much more soluble in chloride than in sulphate media.

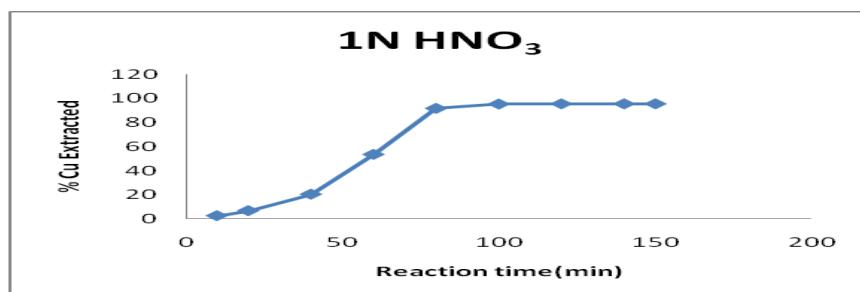


Figure 3

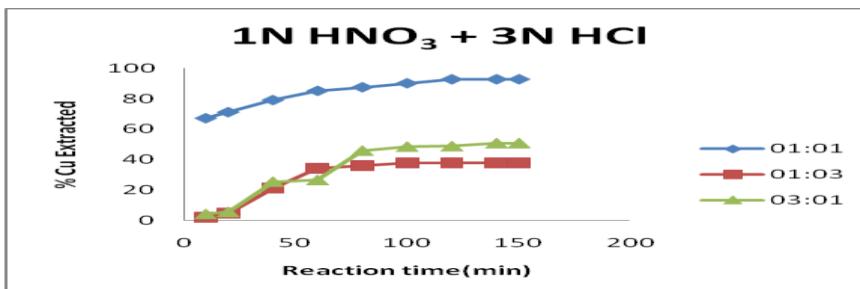


Figure 4

Electro Deposition

The maximum metal dissolved solvent is further sent for electro deposition. In this technique the volts and Time of treatment was varied and % metal coated was calculated. From our pilot scale studies we found that the % metal coated was increased with respect to increase in time of treatment and volts. In our studies we have achieved 38.6% of metal coated over the plate for 10 minutes of treatment at 12V.

CONCLUSIONS

Several researchers reported bench and pilot scale studies for recycling of e-waste. This non thermal method is one of the important methods used for extracting metals from waste PCB's. The metallic parts are leached with solution of different acids of different Conc. or strengths. After removing solid residue the solution is electrolysed to win the metals like copper, etc. The study of leaching process includes the determination of suitable solvents and optimum process parameters like Conc. of acids, temperature, reaction time, etc. The study of electro deposition part includes setting up of an electrolytic cell with different Anode and Cathode materials and determination of optimum process parameter like time of treatment, voltage, etc. The optimization of these two processes will lead to recovery of metals from PCB's and reduce environmental problems.

REFERENCES

1. Kui Huang, Jie Guo and Zhenming Xu printed circuit board: A review of current technologies and treatment status in china, J. of hazardous management Jhazmat, (2008)

2. Masavetas, Nikola O.U, Spanou, Pavlatou Production of Copper Powder From Printed Circuit Boards By Electrodeposition, Global Nest, 11(2) (2009)
3. Agarwal Perween, Shubhajit Pramanik and Sahu K.K., Recovery of copper from pcb leach solution by solvent extraction, Conf. Proceedings national metallurgical laboratory, csir, jamshedpur - 831007, India (2008).
4. Kazuya Koyama, Mikiya Tanaka and Jae-chun Lee, Copper Leaching Behavior from Waste Printed Circuit Board in Ammoniacal Alkaline Solution, Materials Transactions, 47(7) 1788 to 179 (2006).
5. Zong Gao, Jianchi Li, C. Zhang, Printed circuit board Recycling:A State of Art survey, Dept of Industrial Engineering, Texas USA. IEEE (2002).
6. Gramatyka P., Nowosielski R. and Sakiewicz P., Recycling of waste electrical and electronic equipment, -JAMME 20(1-2) (2007).
7. Md Fazlul Bari, Mst. Noorzahan Begum, Shamsul Baharin Jamaludin, Kamarudin, Selective leaching for the recovery of copper from pcb, Hussin School of Materials Engineering, University Malaysia Perlis, 02600 Arau, Malaysia (2012).
8. Chatterjee and Krishna Kumar, Effective electronic waste management and recycling process involving formal and non-formal sectors, Intl J. of Physical Sciences, 4(13),893-905 (2009).
9. Hugo Marcelo Veit et.al, Recovery of copper from printed circuit boards scraps by mechanical processing and electrometallurgy, LACOR, PPGEM, Universidade Federal do Rio Grande do Sul, Campus do Vale (2004).
10. Havlik T., Orac D., Petranikova and Miskufova A., Hydrometallurgical treatment of used printed circuit board after thermal treatment, Elsevier-waste managementj. wasman, (2011)

